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DIEL FLUCTUATIONS IN CATCHES OF JUVENILE BROWN AND WHITE SHRIMP IN A TEXAS ESTUARINE CANAL[1]

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ABSTRACTS

A 2.7-ha portion of a canal near Texas City, Texas, was trawled over a 48-hour period to measure diel fluctuations in catches of juvenile brown shrimp (*Penaeus aztecus*) and white shrimp (*P. setiferus*) and to evaluate the relative influence of selected environmental variables on such fluctuations. No significant day *vs.* night differences were detected in catches of brown shrimp, but catches of white shrimp were significantly ($P < 0.01$) higher during daytime. Observed correlations between catch and tide elevation and temperature were believed to be coincidental.

INTRODUCTION

The continued expansion of the shrimp fishery of the Gulf of Mexico has stimulated renewed interest in the dynamics of exploited populations of juvenile shrimp in estuarine areas. Analytical methods combining fishing-success and mark-recapture data are being evaluated as a means of estimating rates of fishing and natural mortality in these populations (Clark and Caillouet 1973). Because such studies involve sequential sampling the possibility exists for bias from diel changes in activity of shrimp. This study was conducted to measure diel fluctuations in catches of juvenile brown shrimp (*Penaeus aztecus*) and white shrimp (*P. setiferus*) so as to provide the necessary baseline data for use in scheduling sampling work in studies of this nature.

Diel activity patterns of adult brown and white shrimp are well documented. Adult brown shrimp are nocturnal and burrow by day (Hughes 1969), but adult white shrimp are diurnally active and are thought to burrow at night (Idyll 1950). Diel fluctuations in catches of postlarval shrimp also have been studied. Baxter (1964) and Williams and Deubler (1968) found catches of postlarval brown shrimp to be higher at night than during daytime in Texas and in North Carolina, respectively; and Caillouet, Fontenot and Dugas (1968) obtained similar results for white shrimp in Louisiana. However, St. Amant, Broom and Ford (1966) and Caillouet, Perret and Dugas (1970) were unable to show any relationship between catches of postlarval brown shrimp and time of day in Louisiana waters. In the case of juveniles, Joyce (1965) observed high catches of

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juvenile brown shrimp during daylight hours in northeast Florida, and Trent (1967) reported both diurnal and nocturnal emigration, although the shrimp were observed to travel nearer the bottom during daylight hours. However, King (1971) reported that emigration in juveniles of this species occurred exclusively at night. Pullen and Trent (1969) sampled emigrating juvenile white shrimp during daylight hours and observed a similar pattern of movement.

The effects of other environmental variables on diel activity patterns also have been considered. General agreement exists that catches of brown and white shrimp postlarvae are higher at flood tide than at other tidal stages (Copeland and Truitt 1966; St. Amant *et al.* 1966; Caillouet *et al.* 1968), although Caillouet *et al* (1970) observed peak catches of postlarval brown shrimp on both high and low tides. Emigrating juvenile brown shrimp have been reported to move only on ebb tides (King 1971). Temperature and salinity changes may also influence diel activity patterns. Aldrich, Wood and Baxter (1968) observed pronounced activity changes in postlarval brown shrimp in response to slight variation in temperature. However, King (1971) found no correlation between catches of emigrating juvenile brown shrimp and changes in temperature or salinity.

STUDY AREA AND METHODS

The study was conducted in a 2.7-ha portion of a man-made canal opening into Dollar Bay near Texas City, Texas (Fig. 1). The portion sampled is approximately 915 m long and averages 30 m in width. The bottom consists of mixed mud and shell. Average depth is approximately 1.5 m. The canal is bordered by earthen-fill levees surrounded by broad expanses of tidal marsh. During the study, salinities in this area were low (under 10‰), turbidity was high, and tidal amplitude approximated 20 cm.

During a 48-hour period (July 6–8, 1973) 96 sequential 5-minute tows were made in the canal at half-hour intervals with a 3-m otter trawl (2.5-cm stretched mesh). Consecutive tows were made in opposite directions to compensate for possible effects of changes in speed and direction of tidal current. Prior to each tow, tide elevation[2] was recorded and water temperature was measured to the nearest C. Salinity was measured to the nearest part per thousand at 8-hour intervals. Following each tow, the shrimp caught were identified to species, counted and total length (tip of rostrum to tip of telson) was measured to the nearest millimeter. In tows in which the number of individuals of either species exceeded 50, subsamples of 50 individuals of that species were measured; otherwise, all individuals were measured.

RESULTS AND DISCUSSION

Catches of brown and white shrimp, and tide elevation and water temperature, are plotted against Central Standard Time in Figure 2. The cross-hatched area indicates "night," which includes the period from one-half hour after sunset to one-half hour before sunrise. For all catches combined, the mode in total length of brown shrimp was 90 mm (range, 46–114 mm); the mode for white shrimp was 60 mm (range, 35–97 mm). Brown shrimp catches exhibited no obvious diel cycle, but white shrimp catches were lower during the hours of darkness than

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[2] This refers only to measured changes during the study, and it does not apply to absolute heights above or below some standard such as mean sea level.

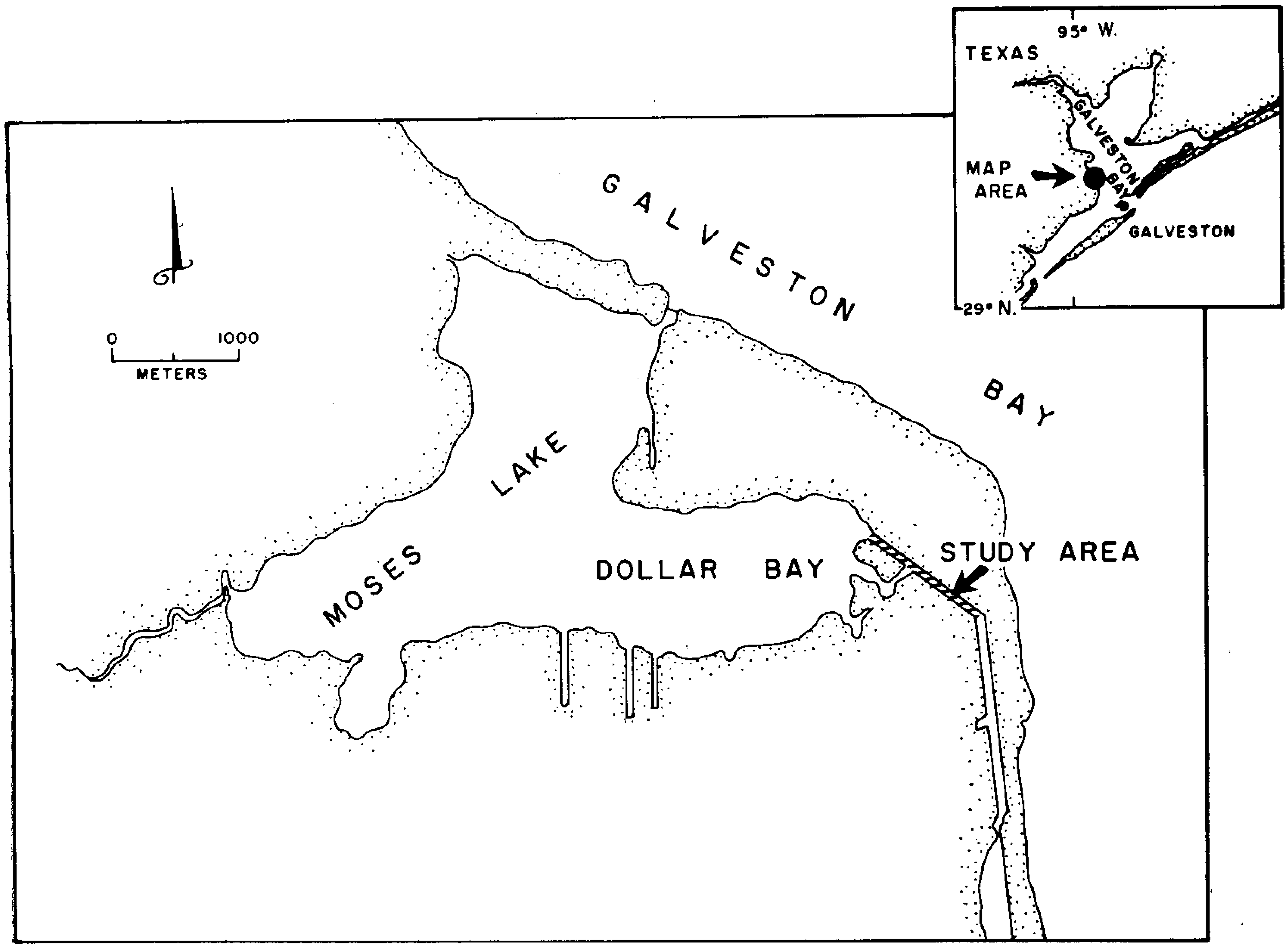

FIG. 1. Map of Dollar Bay and vicinity, Texas City, Texas, giving location of the study area.

during daytime (Fig. 2). Analysis of variance[3] revealed no significant day-to-day or light *vs.* darkness (day *vs.* night) differences in brown shrimp catch (Table 1), but a significant ($P < 0.01$) difference occurred between daytime and night catches of white shrimp (Table 2).

Our results for brown shrimp are similar to those reported by Joyce (1965) and by Trent (1967) and suggest a tendency for diurnal activity under turbid (or cloudy) conditions; King's (1971) study indicates that a closer relationship may exist between diel activity patterns and the light-dark cycle where water is clearer. Similarly, Eldred, Ingle, Woodburn, Hutton and Jones (1961) reported diurnal activity in juvenile pink shrimp (*Penaeus duorarum*), although pronounced activity changes in response to the light-dark cycle also have been documented in the field (Fuss 1964) and under laboratory conditions (Fuss and Ogren 1966; Hughes 1969). Hughes (1969) was able to demonstrate a circadian rhythm of pink shrimp activity in phase with the light-dark cycle; further, he observed an extremely close relationship between emergence from the substrate and the timing of the light-dark transition. It is possible that a similar rhythm exists in juvenile brown shrimp which is subject to modification under turbid or cloudy conditions.

[3] Because the number of tows differed between daytime and night, a method for proportional subclass numbers was used.

The possible influences of salinity, tide and temperature remain to be considered. Salinity remained approximately 9‰ throughout the study and had no apparent influence on catch of either species. However, a significant ($P < 0.01$) negative correlation ($r = -0.35$) was observed between transformed catches (see Table 1) of brown shrimp and tide elevation, suggesting that tide may have

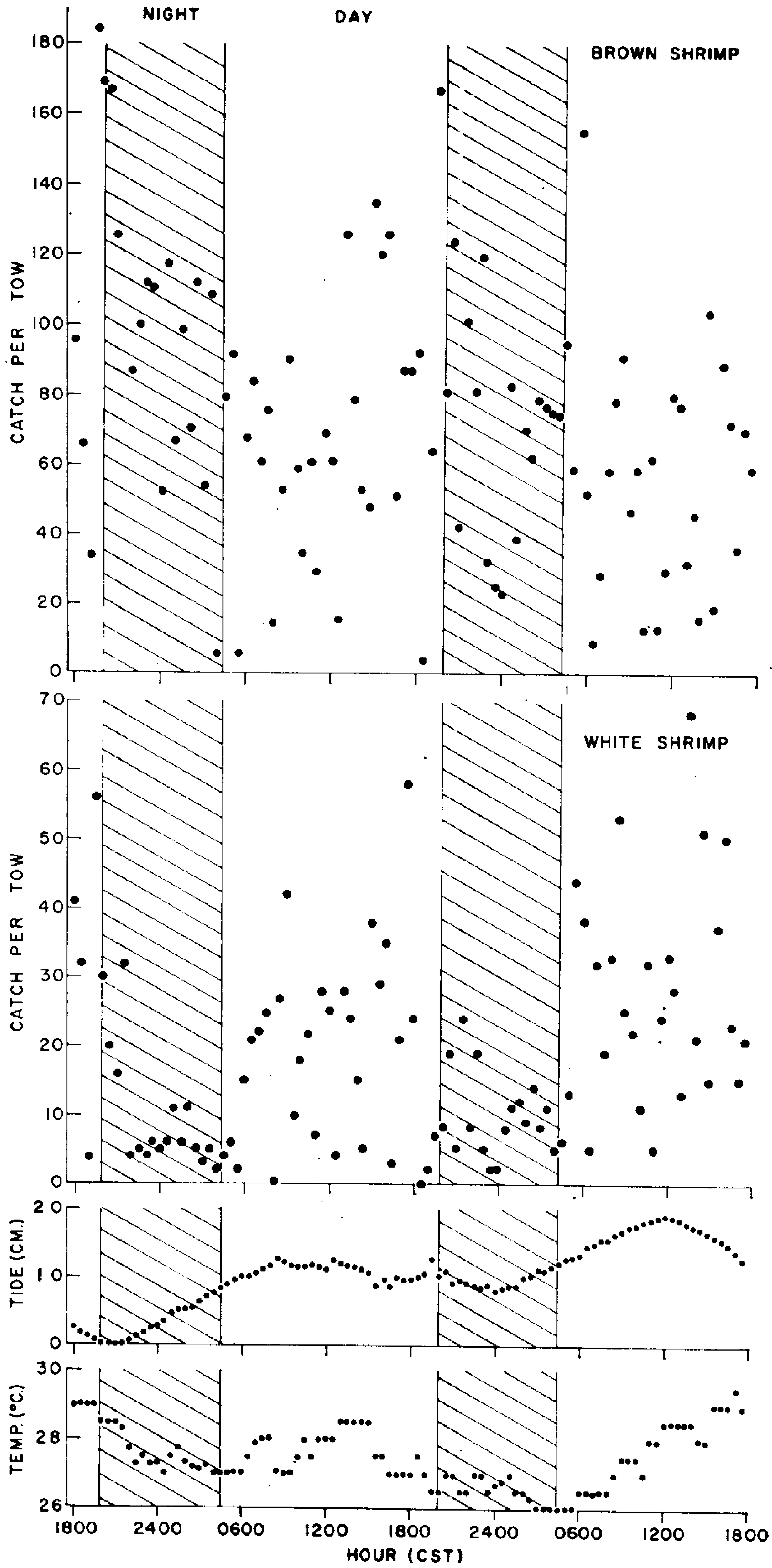

FIG. 2. Fluctuations in catches of brown and white shrimp per tow, tidal elevation (cm) and water temperature (°C) during 48 hours of sampling.

influenced catch in this species. In addition, significant ($P < 0.01$) positive correlations were found between transformed catches (Table 2) of white shrimp and tide elevation and water temperature ($r = 0.28$ and $r = 0.30$, respectively). Because tide elevation and water temperature were lower during the hours of darkness and higher during daylight hours (Fig. 2), the possible influences of these two factors are confounded with the light-dark cycle. We believe, however, that these correlations reflect a coincidence of changes in temperature and tide elevation with time of day and that white shrimp, but not brown shrimp, responded more to the light-dark cycle than to change in salinity, temperature, or tide elevation.

TABLE 1

Analysis of variance of transformed catches[a] of brown shrimp, July 6–8, 1973

Source of variation	Degrees of freedom	Sum of squares	Mean square	F
Days, D	1	0.27	0.27	2.25
Time[b], T	1	0.32	0.32	2.67
D × T interaction	1	0.10	0.10	0.83
Error	92	11.02	0.12	

[a] Log_{10} (catch). A logarithmic transformation was used to normalize the data.
[b] Light vs. darkness.

TABLE 2

Analysis of variance of transformed catches[a] of white shrimp, July 6–8, 1973

Source of variation	Degrees of freedom	Sum of squares	Mean square	F
Days, D	1	0.10	0.10	1.00
Time[b], T	1	2.24	2.24	17.23**
D × T interaction	1	0.01	0.01	0.07
Error	92	12.28	0.13	

[a] Log_{10} (catch + 1). Because some catches were zero, 1 was added to each catch prior to transformation. A logarithmic transformation was used to normalize the data.
[b] Light vs. darkness.
** Significant at $P < 0.01$.

LITERATURE CITED

ALDRICH, D. V., C. E. WOOD and K. N. BAXTER. 1968. An ecological interpretation of low temperature responses in *Penaeus aztecus* and *P. setiferus* postlarvae. *Bull. mar. Sci Gulf Caribb.* **18:** 61–71.

BAXTER, K. N. 1964. Abundance of postlarval and juvenile shrimp. *Circ. Fish Wildl. Serv. Wash.* **183:** 28–29.

CAILLOUET, C. W., JR., B. J. FONTENOT and R. J. DUGAS. 1968. Diel fluctuations in catch of postlarval white shrimp, *Penaeus setiferus* (Linnaeus), with the Renfro beam trawl. *Bull. mar. Sci. Gulf Carrib.* **18:** 829–835.

————, W. S. PERRET and R. J. DUGAS. 1970. Diel fluctuations in catch of postlarval brown shrimp, *Penaeus aztecus* Ives, with the Renfro beam trawl. *Bull. mar. Sci. Gulf Caribb.* **20:** 721–730.

CLARK, S. H. and C. W. CAILLOUET, JR. 1973. White shrimp (*Penaeus setiferus*) population trends in a tidal marsh pond. *Mar. Fish. Rev.* **35**: 27–29.

COPELAND, B. J. and M. V. TRUITT. 1966. Fauna of the Aransas Pass Inlet, Texas. II. Penaeid shrimp postlarvae. *Tex J. Sci.* **18**: 65–74.

ELDRED, B., R. M. INGLE, K. D. WOODBURN, R. F. HUTTON and H. JONES. 1961. Biological observations on the commercial shrimp, *Penaeus duorarum* Burkenroad, in Florida waters. *Prof. Pap. Ser. Fla. St. Bd Conserv.* No. **3**. 139 p.

FUSS, C. M., JR. 1964. Observations on burrowing behavior of the pink shrimp, *Penaeus duorarum* Burkenroad. *Bull. mar. Sci. Gulf Caribb.* **14**: 62–73.

——————and L. H. OGREN. 1966. Factors affecting activity and burrowing habits of the pink shrimp, *Penaeus duorarum* Burkenroad. *Biol. Bull. mar. biol. Lab., Woods Hole.* **130**: 170–191.

HUGHES, D. A. 1969. Factors controlling the time of emergence of pink shrimp *Penaeus duorarum*. In: Mistakidis, M. N. (ed.). *FAO Fish. Rept.* **57**(3): 971–981.

IDYLL, C. P. 1950. The commercial shrimp industry of Florida. *Ed. Ser. Fla. Bd Conserv.* No. **6**. 31 p.

JOYCE, E. A. 1965. The commercial shrimps of the northeast coast of Florida. *Prof. Pap. Ser. Fla. St. Bd Conserv.* No. **6**. 224 p.

KING, B. D., III. 1971. Study of migratory patterns of fish and shellfish through a natural pass. *Tech. Ser. Tex. Parks Wildl.* No. **9**. 54 p.

PULLEN, E. J. and W. L. TRENT. 1969. White shrimp emigration in relation to size, sex, temperature and salinity. In: Mistakidis, M. N. (ed.). *FAO Fish. Rept.* **57**(3): 1001–1014.

ST. AMANT, L. S., J. G. BROOM and T. B. FORD. 1966. Studies of the brown shrimp, *Penaeus aztecus*, in Barataria Bay, Louisiana. *Proc. Gulf Caribb. Fish. Inst.* **18**: 1–17.

TRENT, L. 1967. Size of brown shrimp and time of emigration from the Galveston Bay system, Texas. *Proc. Gulf Caribb. Fish. Inst.* **19**: 7–16.

WILLIAMS, A. B. and E. E. DEUBLER. 1968. A ten-year study of meroplankton in North Carolina estuaries; assessment of environmental factors and sampling success among bothid flounders and penaeid shrimps. *Chesapeake Sci.* **9**: 27–41.